

PROJECT ADMINISTRATION DATA SHEET☒

ORIGINAL

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REVISION NO. \_\_\_\_\_

Project No. E-19-507 \*DATE: 7/21/81Project Director: Dr. R.F. Hochman School/~~EES~~ Chemical EngineeringSponsor: DHHS/PHS National Institute of Dental ResearchType Agreement: Grant 2-T32-DE07053-06Award Period: From 7/1/81 To 6/30/82 (Performance) ----- (Reports)Sponsor Amount: \$93,101 (06 year) Contracted through:Cost Sharing: \$647 (E-19-221)~~OTR~~ GITTitle: Postdoctoral - Predoctoral Training in Dental MedicineADMINISTRATIVE DATAOCA CONTACT Duane Hutchison X 48201) Sponsor Technical Contact: Thomas M. Valega, Ph.D.; Chief Restorative MaterialsProgram Branch; Extramural Programs, NIDR; Public Health Service; Dept. of  
Health & Human Services; Bethesda, MD 20205 (301)496-74912) Sponsor Admin./Contractual Contact: Robert Ginsburg; Grants Management Officer;Extramural Programs, NIDR; Public Health Service; Dept. of Health and Human  
Services; Bethesda, MD 20205 (301)496-7437Reports: See Deliverable Schedule Security Classification: noneDefense Priority Rating: noneRESTRICTIONSSee Attached NIH Supplemental Information Sheet for Additional Requirements.Travel: Foreign travel must have prior approval - Contact OCA in each case. Domestic travel requires sponsor approval where total will exceed greater of \$500 or 125% of approved proposal budget category.Equipment: Title vests with GIT; however, we are accountable for all equipment purchased.COMMENTS: \* Continuation of E-19-587COPIES TO:Administrative Coordinator  
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SPONSORED PROJECT TERMINATION SHEETDate 6/30/83Project Title: Postdoctoral-Predoctoral Training in Dental MedicineProject No: E-19-507Project Director: Dr. Robert F. HochmanSponsor: HHS/PHS/NIH, National Institute of Dental ResearchEffective Termination Date: 6/30/82Clearance of Accounting Charges: 6/30/82 (06 year)

Grant/Contract Closeout Actions Remaining:

- ☐ Final Invoice and Closing Documents
- ☒ Final Fiscal Report
- ☒ ~~Final~~ Report of Inventions Interim
- ☐ Govt. Property Inventory & Related Certificate
- ☐ Classified Material Certificate
- ☐ Other \_\_\_\_\_

Final Report submitted with request for continuation  
of funding per Dr. Hochman 6/13/83.

Assigned to: Chemical Engineering (School/~~Laboratory~~)COPIES TO:

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## I. Summary

Recognizing the expanding need for delivery of dental restorative care to our country's populace, recognizes the need for less costly, more workable, more reproducible, more stable and more reliable restorative materials, whether they be for fillings, crowns, bridges or implants. To achieve these needs requires extensive improvement in dental materials is still possible. However, to achieve this goal requires well trained and dedicated university staff and research personnel. These people must be trained and the proposed program is designed to achieve this end through a blend of:

- a) fundamental classroom and laboratory instruction,
- b) supplemental training through seminars and short courses,
- c) interaction with dental school environment and practicing dentists,
- d) research training problems closely related to dental restorative materials needs.

In addition nondental trainees will have a special orientation program designed to stimulate and challenge them with the basic problems in dental restorative materials. Postdoctoral trainees will be selected from DDS's and Ph.D.'s with indicated interests in the area. DDS trainees will be solicited from across the country.

The major training will be conducted by an extremely competent staff in metallurgy and materials. All have stature nationally and several are recognized internationally. Strength ranges from physical metallurgy and structure property correlations to special techniques (FIM, SEM, STEM, x-ray, diffraction, neutron diffraction, etc.) and corrosion. Auxiliary training is also available in ceramics, polymers and composites. All of these areas are vitally important to achieving advances in dental materials.

Extensive facilities in all phases of modern materials research are available to trainees. Recent equipment expansion has furthered the structure analysis, mechanical property and corrosion laboratories. The trainee will have all the most modern and sophisticated facilities available for their research training.

Over the past 16 years training in dental materials has reached maturity at the Georgia Institute of Technology. The program has developed thirteen active dental materials research personnel, 4 in dental schools, one at Johns Hopkins, one devoting essentially full time to dental-medical materials at Georgia Tech, one part time practice and part time at Emory, and three devoting part time to dental-medical materials research. Three other former dental students trainees are active in materials related studies. All have made significant contributions in their areas.

The proposed program is designed to provide maximum training by providing proper academic direction and counseling as well as direction for the trainee research to achieve the greatest contribution to the student's growth. All of this has been designed with a critical number of trainees to achieve superior results with a minimum of personnel costs. The proposed training program, the staff, the facilities and the experience, coupled with the interaction with two dental schools, provides the best guarantee that the trainees on this program will develop the background necessary to contribute to dental materials research.

## II. Background of Dental Materials Training at the Georgia Institute of Technology

### A. Review - Past Trainees

The initial dental materials program at Georgia Tech started in July of 1963 under the direction of the present program director who's involvement in medical-dental materials started in 1957. As the program developed it broadened from strictly graduate training to include postdoctorals, and for a period of time training of dental students in the summer. Its major function was to provide the trainees with a strong background in metallurgy, ceramics and polymers, plus training in the use and application of new research tools and techniques in dental materials research problems. As the program developed more and more interplay between dental and physical science oriented personnel occurred. It is obvious that in addition to the trainees on the program a large number of Tech staff in Engineering, the Physical Sciences and the Biological Sciences have become much better acquainted with basic problems and the requirements in dental materials research. Broadening of the dental face of the program has resulted through contacts with the Emory Dental School, the Dental School of the Medical College of Georgia and recently a cooperative program by Dr. Marek with Dr. Mahler of the University of Oregon, a proposed program with the University of Pacific between Dr. Ryge and Dr. Hochman, and more recently, cooperative studies are planned with the University of North Carolina in the corrosion research of semi-precious and non-precious dental restorative materials.

The work of our trainees to date has resulted in 9 theses and more than 30 papers on dental-medical materials research. For a period in the late 1960's and early 70's more than 25 dental students were trained in special summer research training programs. These studies resulted in a number of special projects which received not only local awards, but two projects were finalist in the National Table Clinics, with the work of two trainees DDS's, Fred and Aubrey receiving a second nationally in 1968. Dr. Stephen Fred, DDS, until recently was researcher at the National Institute of Dental Research. Trainees who have been trained in dental materials and are engaged in direct or related dental material research at Georgia Tech are:

Dr. L. D. Love, DDS - Professor, Temple University Dental School.

Dr. T. Okabe - Associate Professor of Dental Materials,  
Dental School Medical College of Georgia.

Dr. M. Marek - Associate Professor of Metallurgy,  
Georgia Institute of Technology.

Dr. A. Villastrigo, DDS - a trainee went to dental school after training,  
now a part-time professor at the Dental School  
the University of Texas, San Antonio.

Dr. K. J. Bundy - Assistant Professor, Department of Materials  
Johns Hopkins University.

Dr. F. M. Butler, DDS - part-time staff member at Emory University  
Dental School and part-time practicing periodontist.

Dr. C. Y. Kung - Postdoctoral Research Scientist, Depart of Materials,  
University of California.

Dr. S. Frieman - Senior Research Scientist, National Bureau of Standards,  
Gaithersburg, Maryland.

Dr. J. W. Koger - Senior Research Metallurgist,  
Oak Ridge National Laboratory.

Dr. R. J. Mitchell - M.S. in Metallurgy Area at Tech then to  
University of Virginia for Ph.D., now  
Research Scientist, Dental School of the Medical  
College of Georgia.

In addition four other trainees on the program are still actively engaged in metallurgical materials research that can relate to dental-medical products. They are:

Dr. E. L. Ling - Products Research Laboratories,  
St. Joseph Mineral Corporation.

Mr. J.C. Caron - Texas Instruments,  
Dallas, Texas

Mr. J.A. Quintal - Electronic Industries,  
Hartford, Conn.

Mr. F. J. Topolski - Western Electric-Bell Telephone Laboratories,  
Atlanta, Georgia.

## B. Present Trainees

At this time there are three full time predoctoral candidates; Mr. Peter Bilstoft, Mr. Larry Rogers, and Ms. Cheryl Espy, and two postdoctorals, Dr. Steven Reese and Dr. Pathik Soni ( a U.S. Resident). Summary descriptions of the program for each of the trainees including areas are described in the following:

### Postdoctorals

Dr. Steven B. Reese, D.D.S. Dr. Reese has now completed his second training year. His research work, which is the beginning of his M.S. thesis studies, is on the kinetics of copper reaction in dental amalgam. His work in conjunction with the grant director and Dr. Marek was accepted for presentation at the March A.A.D.R. Meeting in 1980. In addition he has developed a very unique clinical program at Emory University in which he is studying dental amalgams implanted in dentures so as to be able to have them available for easy access for corrosion evaluation. He is also beginning to gain teaching experience by providing lectures on the biological aspect of dental-medical materials, and spending time at Emory University working with their staff and providing classroom lectures and clinical teaching. Dr. Reese is planning to continue in the dental materials area and has submitted an application for Career Development Award. He has obtained an indepth background in metallurgy and materials and will receive a Master of Metallurgy. This has not been a direct goal of his program but has been an outgrowth of intensive study as well as good thesis research.

Dr. Pathik Soni, D.D.S. Dr. Soni is an American immigrant who has had experience at the University of Michigan and the University of Northwestern. Dr. Soni had a paper of his own in 1979 entitled "Comparison of the Accuracy of Denture Bases by a Non Parametric Method," in the Journal of Oral Rehabilitation, Vol. 1, 35-39, Jan. 1979. In addition he has provided lectures on dental restorative materials at the American Society of Metals meeting in April 1979 and was the winner of first place in an ASM poster competition for the local American Society for Metals Chapter. His poster presentation was on dental alloys. An abstract of his work in conjunction with Dr. Hochman on the effect of sodium fluoride on corrosion behavior of dental amalgams was presented as a poster presentation at the AADR Meeting in March 1980, in Los Angeles. In addition Dr. Soni is using quantitative metallography to study corroded dental amalgams. He is also studying the effect of crevice corrosion on natural extracted teeth as well as testing soft polymeric lining materials for the potential ADA specifications. This work is done in conjunction with other members of the program.

### Predotorals

Mrs. Cheryl H. Espy. Mrs. Espy is continuing her work towards a Master of Science Degree in Metallurgy with emphasis on dental materials. The balance of Mrs. Espy's work is principally her graduate thesis research. She has completed preliminary studies on ion-implantation as well as the evaluation of corrosion characteristics of certain types of alloys tested in vitro. Mrs. Espy is broadening her background with biological background courses in addition to physical science studies.

Mr. Larry B. Rogers. Mr. Rogers received his Bachelor of Science Degree from the University of Georgia. He came to this program from Emory Dental School where he was a technician in the dental materials program. This fall he started his research and training full time towards a Master of Science Degree. He has initiated research on the corrosion of precious metal substitute materials.

Mr. Peter Bilstoft. Mr. Bilstoft is a new trainee on the program presently involved in electroplating copper on mercury-silver materials for diffusion studies, accelerated corrosion tests of amalgam and is presently working on the development of

a testing program for corrosion depth analysis. He has expressed an interest in furthering his work in this area and has visited the Dental Research Center at the University of North Carolina at Chapel Hill where he wants to continue after his M.S.

#### C. Potential Trainees

At present we have two DDS's considering doing postdoctoral work, either or both will be available at a time convenient to the potential initiation of this continuation grant. We will also be adding a new predoctoral to replace those graduating prior to the completion of the present grant. Two very capable trainees have applied for this opening, one desiring to go to dental school in the future and the other, a woman desiring to further her career in dental-medical research, and hopes to teach and do research in this area upon completion of her Ph.D. studies. Both are better than 3.5 students. The lady can wait a year which will be in keeping with the possibility that the grant will be continued.

#### D. Research - Theses and Publications

The research on the training programs to date have been principally designed for training, however, the work has also yielded significant results in many areas. Some of the principal contributions have been in the understanding of corrosion and biocompatibility in the oral environment, particularly of dental amalgam and implants; the basic diffusion and reaction kinetics in dental materials; the effects of ultrasonics on material reactions; and the use of ion implantation to improve the fatigue and corrosion resistance of dental alloys which provides the possibility of low cost, high compatible, crown, bridge and implant materials. This research has resulted in ten theses and more than thirty papers idrectly or indirectly related to the research on the training programs to date. A list of these publications is provided below:

##### 1. Theses

- a) Butler, M.F., "Bacteriostatic Effects of Corrosive Products from Metals Applicable to Dental Materials for the Purpose of Decay Prevention." M.S. in Metallurgy (Dental Materials)
- b) Villastrigo, A.C., "Tranishing of Dental Gold Alloys." M.S. in Metallurgy (Dental Materials)
- c) Quintal, J.A., "The Effect of Ion Implantation on Dental-Medical Alloys." M.S. in Metallurgy (Dental Materials)
- d) Chien, K. H., "The Effect of Ordering on Low Cycle Fatigue of  $\text{Cu}_3\text{Au}$ ." Ph.D. in Metallurgy (dental Materials)
- e) Love, L.D., "Corrosion Characteristics of Dental Amalgam." M.S. in Metallurgy (Dental Materials)
- f) Topolski, F.J., "The Effect of Ultrasonics on the Physical and Mechanical Properties of Metals." M.S. in Metallurgy (Dental Materials)
- g) Horne, E.W., "Order Strengthening in Equiatomic Copper-Gold." M.S. in Metallurgy (Dental Materials)
- h) Caron, J.C., "The Effect of Hich Condensin Pressures and Ultrasonics on the Hardness of Dental Amalgams." M.S. in Metallurgy (Dental Materials)

- i) Freiman, S.W., "Diffusion of Mercury into Silver-Tin Dental Alloy (Ag<sub>3</sub>Sn) Including the Effect of Ultrasonic Energy." M.S. in Metallurgy (Dental Materials)
- j) Koger, J.W., "A Study of the Kinetics of the Mercury Reaction with the Silver-Tin Dental Alloys." M.S. in Metallurgy (Dental Materials)

## 2. Major Papers Presented and Published

A list of the major papers delivered in relation to the Georgia Tech dental materials program follows. The seeming slow period in 1976-77 is during the initiation of the new grant. With active trainees the publications have greatly increased in the past two years.

- a) "A Study of Fatigue and Corrosion Fatigue of Surgical Implant Materials and Ion plated and Implanted Materials," R. F. Hochman and M. Marek. Proceedings of the First World Biomaterial Conference, Vienna, Austria, April 8-12, 1980.
- b) "The Effect of Sodium Fluoride on the Corrosion Behavior of Dental Amalgams," R. F. Hochman, P.M. Soni and M. Marek. Published on Conference Microfilm Proceedings, AADR, 1980 Annual Conference, Los Angeles, CA, March 20-23, 1980.
- c) "Low Temperature Diffusion of Copper in  $\alpha_1$  and  $\beta_1$  Phase of Dental Amalgam," R. F. Hochman, S. Reese and Marek. Published on Conference Microfilm Proceedings, AADR, 1980 Annual Conference, Los Angeles, CA, March 20-23, 1980.
- d) "Comparison of the Accuracy of Denture Bases by a Non Parametric Method," P. Soni, Journal of Oral Rehabilitation B (1), 35-39 January 1979.
- e) "An Analysis of In Vivo and In Vitro Biomaterials Properties and Service Characteristics of Orthopedic Implants," R. F. Hochman, M. Marek and K. Bundy. Trans. 11th Int. Biomat. Symp. 3, 126, 1979.
- f) "Bacteriostatic Effects of Pure Metals," R. F. Hochman, K. J. Bundy, and M. F. Butler, J. Biomed. Mat., in press.
- g) "Solution Chemistry of Crevices and Stress Corrosion Cracks," R. F. Hochman and M. Marek and J. G. Rinker, Proceedings of the 6th International Congress on Metallic Corrosion, ICME Australia, 1978, pp. 445-461.
- h) "Material Failure in Medical-Dental Devices," R. F. Hochman - SAMPE, Quarterly, Jan. 1978, pp. 28-33.
- i) "Mechanism of Crevice Corrosion of Dental Amalgam," M. Marek and R. F. Hochman Paper presented to the 53rd Session of the IADR, London, April 1975 (DMG microfilm).
- j) "In Vitro Corrosion of Dental Amalgam Phases," M. Marek, T. Okabe and R. F. Hochman, Paper presented to the 1975 General Session of the AADR, New York, April 1975 (DMG microfilm).



- k) "In Vitro Corrosion of Dental Amalgam Phases," M. Marek, T. Okabe and R.F. Hochman, Accepted for publication, Journal of Biomedical Materials Research. Based in part on the preceding paper.
- l) "Auger Analysis of Surface Films on Ag<sub>3</sub>Sn," H.E. Grenga, J.L. Carden, T. Okabe, R. F. Hochman, J. Biomed. Mater. Res., Vol. 9, pp. 207-211 1975.
- m) "Amalgamation Reaction on Mercury-Plated Dental Alloy (Ag<sub>3</sub>Sn)," T. Okabe, R. F. Hochman and L. O. Sims, J. Biomed. Mater. Res., Vol. 9, pp. 221-236 1975.
- n) "Tracer Diffusion of Silver and Tin in a Dental Alloy (Ag<sub>3</sub>Sn)," T. Okabe, R. F. Hochman and M.E. McLain, J. Biomed. Mater. Res., Vol. 8, pp. 381-392 1974.
- o) "A Study of Simulated Stress Corrosion Crack Tip Electrochemical Reaction," R. F. Hochman, R. Piccinini, M. Marek and A.J.E. Pourbaix, Proc. of Conf. on Localized Corrosion, NACE 1974.
- p) "Passivity of Dental Amalgam," M. Marek and R. F. Hochman, paper presented at the TMS-AIME/IMD and ASM/MSD Session, 1972 Materials Engineering Congress, Cleveland, Ohio, 1972.
- q) "A Study of Localized Corrosion Cell Reactions," M. Marek and R.F. Hochman, Proceedings of the 1973 NACE Corrosion Science Symposium.
- r) "Crevice Corrosion in Dental Amalgam Restorations," M. Marek, M.F. Butler and R.F. Hochman, paper presented at the 51st Session of the IADR, Washington, D.C., 1973.
- s) "The Corrosion Behavior of Dental Amalgam Phases as a Function of Tin Content," M. Marek and R.F. Hochman, paper presented at the 51st Session of the IADR, Washington, D.C., 1973.
- t) "Advances in Dental-Medical Implant Materials," Plenary Lecture, 65th Meeting European Federation of Corrosion, Dubrovnik, Yugoslavia, April 18, 1972, Published in Conference Proceedings and CEBELCOR Report.
- u) "Corrosion Behavior of Amalgam Electrodes in Artificial Saliva," M. Marek and R. F. Hochman, Proceedings, 50th Meeting of IADR, March 23, 1972, Las Vegas, Nevada.
- v) "Kinetic Factors in Amalgamation of Dental Alloy," T. Okabe, R.F. Hochman and M.E. McLain, Proceedings 50th Meeting of IADR, March 23, 1972, Las Vegas, Nevada.
- w) "Amalgamation Reaction of Tin, Silver and Dental Alloys (Ag<sub>3</sub>Sn)," T. Okabe, F. Ling and R.F. Hochman, J. Biomed. Mater. Res., Vol. 6, pp. 553-573, 1972.
- x) "Crystallography and Kinetics of Stress Corrosion Cracking of Type 316 Stainless Steel Single Crystals," M. Marek and R.F. Hochman, Vol. 27, No. 9, Sept., 1971, NACE, Houston, Texas.
- y) "Review of Metal Base Dental-Medical Implant Materials," R.F. Hochman, presented April 16, 1970, Clemson University, Proceedings, Materials for Implant Dentistry, to be published.

- z) "Fatigue Properties of Implants," R.F. Hochman, presented at National Meeting, AIME, February 1969, New York, N.Y.
- aa) "High Strength Amalgams Produced by Changing the Fracture Characteristics with Different Condensing Methods," R.F. Hochman and J.C. Caron, Presented March 21, 1968, Houston, Texas, Proceedings of the 1968 IADR Meeting.
- bb) "Improved Properties of 316L Stainless Steel Implants by Low Temperature Stress Relief," R.F. Hochman and L.M. Taussig, Presented by R.F. Hochman at the joint ASM-ASTM Symposium on Orthopedic Materials, Detroit, Michigan, published by J. of Materials, Vol. 1, No. 2, ASTM, June 1966.
- cc) "The Kinetics of the Mercury Reaction with Silver-Tin and the Effects of Ultrasonics of this Reaction," F.R. Hochman, J.W. Koger and S.W. Freiman, presented by R.F. Hochman at the Proceedings of the Meeting of the IADR, July 1965, Toronto, Canada.
- dd) "The Effect of Ultrasonic Energy on Diffusion and Sintering," R.F. Hochman, S.W. Freiman and R.M. Gray, presented by R.F. Hochman, June 23, 1965, at an International Conference on Sintering and Related Phenomena, published.
- ee) "Metals in the Human Body," R.F. Hochman, Metals Review, Vol. XXXVII, No. 8, August 1964, American Society for Metals, Cleveland, Ohio.

This list represents only the major presentations and publications and does not include numerous presentations and lectures to technical, dental and medical groups by members of the program staff and trainees, and a particular series of presentations by R.F. Hochman on "Advances in Dental-Medical Materials," at more than twenty meetings across the country.